1. Name of Experiment: **US-NA61**

This document presents an outline of the US-NA61 measurement program. A complete discussion of the program can be found in the DOE proposal and CERN/SPSC NA61/SHINE proposal addendum, which are both located here.

2. **Physics Goals**
    a. Primary:
        i. The goal of the US-NA61 collaboration is to measure precisely hadron production that is crucial to the accelerator neutrino program at Fermilab and elsewhere.
    b. Secondary:
        i. Incorporate hadron production measurements into neutrino beam simulations for current and future Fermilab neutrino experiments
3. **Expected location of the experiment/project:**
    a. CERN North Area
4. **Particle source:**
    a. CERN North Area H2 beam
5. **Primary detector technology:**
    a. Superconducting spectrometer that employs a large gas TPC
6. **Short description of the detector:**
    a. The NA61/SHINE detector uses the superconducting spectrometer and gas TPC system built for the NA49 experiment. It resides in CERN's North Area on the H2 beamline. The H2 beamline is capable of delivering incident protons, pions, and kaons in the 30-350 GeV energy range. That range is excellent for studying hadron production relevant for neutrino beams derived from Fermilab's 120 GeV Main Injector accelerator complex.
7. **List key publications and/or archive entries describing the project/experiment.**
    a. US-NA61 DOE proposal and the ADDENDUM TO THE NA61/SHINE PROPOSAL: SPSC-P-330, both may be found at either:
        i. http://lbne2-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=9882
        ii. or here.
8. **Collaboration:**
    a. College of William and Mary, Fermi National Accelerator Laboratory, Los Alamos National Laboratory, University of Colorado, University of Pittsburgh, University of Texas Austin
    b. A list of collaborators may be found here
9. **R&D**
    a. Small R&D effort for new electronics (Pittsburgh) and a new forward gas TPC (Colorado)

b. Benefit lies in new hadron production data for neutrino experiments

10. Primary physics goal expected results/sensitivity:

a. We expect to obtain hadron production results with roughly 3M events per incident energy and target material which will lead to statistical errors in the 1% range in P and Pt bins relevant for neutrino beam simulations

b. The dominant systematics are due to the calibration of drift velocity and dE/dx measurements in the gas TPCs. As previous NA61 measurements they will be controlled by real-time measurements and internal data consistency, which have allowed systematic errors on absolute cross sections below 3%. See Figure 1 below.

c. List other experiments that have similar physics goals:

i. MIPP experiment at Fermilab (finished some time ago)

11. Secondary Physics Goal

a. The goal for neutrino flux predictions, when NA61 constraints are incorporated, is a 3-4% error for Fermilab LBL beams

12. Experimental requirements

a. US-NA61 is currently scheduled to run in October 2015 for 4 weeks. We anticipate a similar run roughly a year later, which will incorporate the new forward TPC. The table in Figure 2 shows the initial run plan and also possible future run configurations.

13. Expected Experiment/Project timeline

a. Design and development: 10/2014-10/2015

b. Construction and Installation:

c. First data:

i. Pilot run: June, 2012

ii. First physics run: 10/2015

d. End of data taking:

i. We plan to end data taking the end of 2017

e. Final results:

i. Results from the first data run by 10/2017

ii. Results from the last data run by 10/2018

14. Estimated cost range

a. US contribution to the experiment/project:

i. Electronics: $125

ii. Forward TPC: $170k

b. International contribution to the experiment/project:

i. Significant detector and beam resources from CERN

1. Beamline operation
2. Superconducting magnet operation
3. Computational resources and data storage for analysis

c. Operations cost

i. $500k over 4 years (mostly redirected from existing contracts)

15. The Future

a. Possible detector upgrades and their motivation:

i. We have discussed with ANL the possibility of moving the old MIPP Ring Imaging Cherenkov Counter to CERN although a proposal has yet to be formulated

b. Potential avenues this project could open up:

i. It is not clear at this time, but some NA61 measurements may be relevant for cosmic ray antimatter production (e.g. anti-deuterons) in order to better understand standard production mechanisms, for example antiproton-proton interactions
ii. US-NA61 results may motivate further hadron production measurements

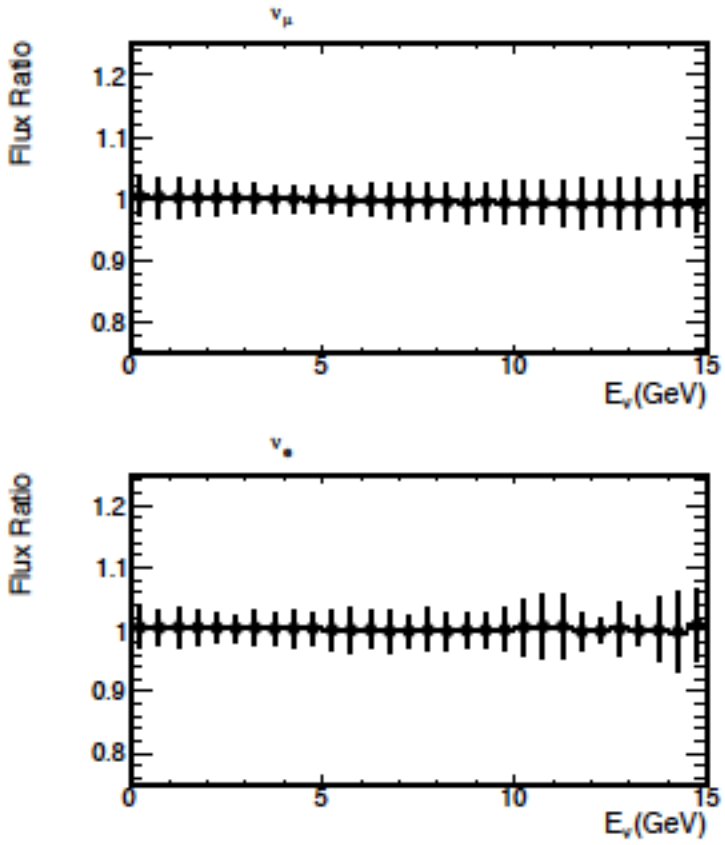

Figure 5: Predicted fractional errors on the neutrino flux at the LBNE far site using the assumed NA61 constraints, for ν_μs in the top panel, and for ν_es in the bottom panel.

Figure 1 shows figure 5 from the US-NA61 Addendum.

proton+pion event totals	**Incident proton/pion beam momentum**		
Target	120 GeV/c	60 GeV/c	30 GeV/c
NuMI (spare) replica	(*future*)		
LBNE replica	(*future*)		
thin graphite ($< 0.05\lambda_I$)	3M	3M	(T2K data)
thin aluminum ($< 0.05\lambda_I$)		3M	(*future*)
thin steel ($< 0.05\lambda_I$)	(*future*)	(*future*)	(*future*)
thin beryllium ($< 0.05\lambda_I$)	3M	3M	(*future*)

Table 3: A table of proton+pion event totals for target and beam settings which are relevant to US long baseline neutrino experiments, that would be run after the CERN 2013-14 shutdown. Proton and pion data may be taken simultaneously with the proper trigger settings. The first set of runs, expected in 2015, are labeled with 3M (the number of incident pion and proton triggers), and the other relevant runs would take place in the *future*, possibly during 2016.

Figure 2 shows the initial run program as presented in the USNA61 SPSC NA61 addendum, although the final priorities and run configurations have not yet been finalized.